THE AZOREAN BLACKSPOT SEABREAM, *PAGELLUS BOGARAVEO* (BRÜNNICH, 1768) (TELEOSTEI, SPARIDAE). REPRODUCTIVE CYCLE, HERMAPHRODISM, MATURITY AND FECUNDITY

by

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ABSTRACT. - Reproduction of the blackspot seabream, *Pagellus bogaraveo* (Brünnich, 1768), was studied in Azorean waters. This species is characterised by protandric hermaphrodism. Length at first maturity averages 27.7 cm for males and 34.6 cm for females. Macro and microscopic examination of gonads and gonadosomatic index indicated that spawning occurs once a year between January and April with peak activity in February and March. The length - fecundity equation is: $F = 1028.44\ e^{0.15\ L}$.

RÉSUMÉ. - La reproduction de la dorade rose, *Pagellus bogaraveo* (Brünnich, 1768) a été étudiée aux Açores. L'espèce est caractérisée par un hermaphrodisme protandrique. La longueur à la première maturité est de 27.7 cm pour les mâles et de 34.6 cm pour les femelles. Les examens macro et microscopique des gonades et l'indice gonadosomatique montrent que la ponte a lieu une fois par an, entre Janvier et Avril, avec un pic maximum d'activité en Février et Mars. La relation entre la longueur et la fécondité est: $F = 1028.44\ e^{0.15}$.

Key-words: Sparidae, *Pagellus bogaraveo*, ANE, Azores, Reproduction, Hermaphrodism.

Published information on blackspot seabream, *Pagellus bogaraveo*, includes some notes on reproduction (Williamson, 1910; Olivier, 1928; Sanchez, 1983; Krug, 1983) from British, French, Cantabrian and Morroccan waters, as well as a preliminary study from the Azores. The object of this study was to describe blackspot seabream reproduction in Azorean waters including sex ratio, length and age at first maturity, spawning season, and fecundity.

MATERIAL AND METHODS

Studies on reproduction of the blackspot seabream, sampled from commercial fishing boats and the research vessels "Geralda" and "Noruega", were conducted upon 1581 individuals from October 1982 to June 1986.

Each specimen's fork length was measured to the nearest centimeter and weighed to the nearest 10 g; sex, macroscopic stage of gonad development and gonad weight to the nearest 0.1 g were recorded. The macroscopic stage of gonad development in the fishes was determined using the classical classification of maturity stages: immature; in maturation (I); pre-spawning (II); spawning (III) and post-spawning (IV).

Ovaries used for fecundity estimates were from maturity stage II; small pieces from each pair of ovaries were weighed to the nearest 0.1 mg, placed in

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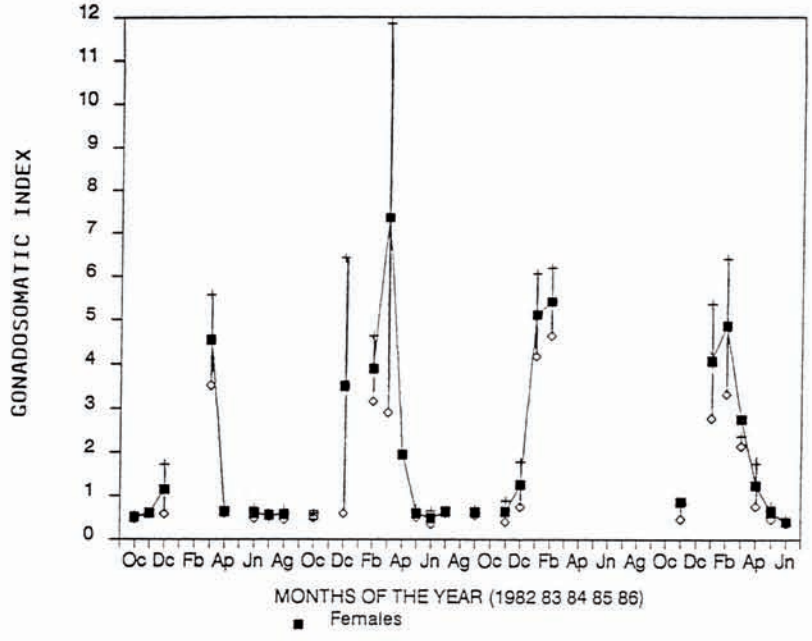


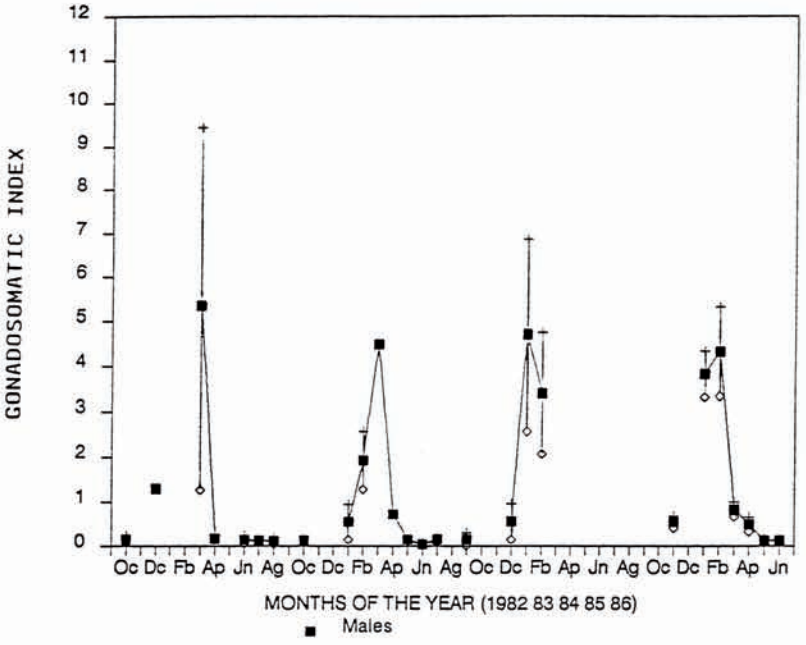


Fig. 1: Gonadosomatic index for female *P. bogaraveo*. October 1982 - June 1986. The symbols + and ◇ represent 95% confidence limits.
Fig. 2: Gonadosomatic index for male *P. bogaraveo*. October 1982 - June 1986. The symbols + and ◇ represent 95% confidence limits.

Gilson's fluid and periodically shaken to release oocytes from the ovarian tissue. After aproximately 3 months, the ovaries were carefully washed under running water which aided in separating oocytes from the tissue. The sample from each ovary was than placed in a 10 x 10 counting grid and all oocytes were counted under a binocular microscope. The formula:

$$Y = \frac{Wy}{w}$$

was used to estimate the number of oocytes in the ovaries. Y is the total number of eggs in both ovaries, W is the weight of both ovaries, w the weight of the sample and y the number of oocytes in the sample.

The gonadosomatic index (GSI) was calculated from gonad weight (w), expressed as a percentage of total weight (W), for 1343 specimens, by the following formula:

$$GSI = \frac{100\ w}{W}$$

RESULTS

Spawning period

To estimate spawning period, macroscopic appearance of gonads as well as microscopic analyses were used. Gonadosomatic indexes were calculated and

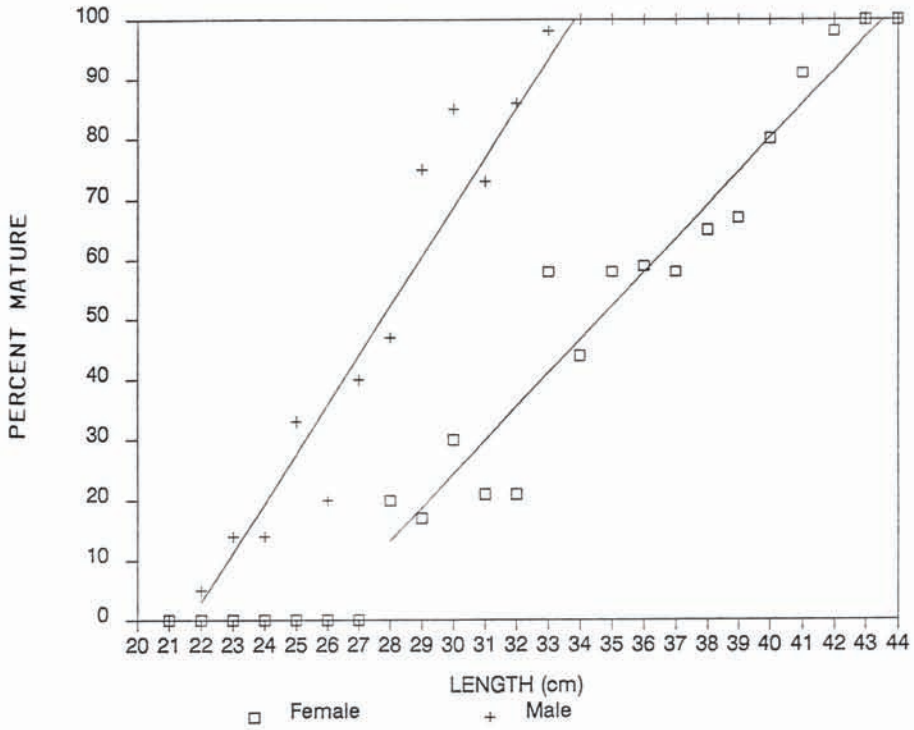


Fig. 3: Length at first maturity for *P. bogaraveo*.

monthly mean values for females and males with the 95% confidence limits are shown in Figures 1 and 2. The highest mean value was found in stage II, where the weight of the gonads represented 7.5% of the total weight for females. Peaks of gonadosomatic indexes, both in males and females, coincided with the spawning period as determined from maturity stage changes.

Length at first maturity

A probit analysis of length at first maturity i.e. L_{50} (length at which 50% of the fish are mature) showed that males were mature at an average of 27.7 cm length and females at 34.6 cm (Fig. 3). This corresponds to lengths at ages 5 and 8, respectively (Krug, 1989). Males mature considerably earlier than females, which is due to the protandric hermaphrodism of the species.

Sex-ratio and hermaphrodism

Of 1581 specimens examined, 288 were juveniles (< 22 cm in length). Histological and macroscopic study showed three gonad types in *P. bogaraveo*: functional testes without ovarian tissue (males); ovotestis; and functional ovaries with a degenerated testicular part (females). These gonads appeared in the ratio of 38% females, 29% males and 32% intersexual individuals. This data showed

Table I: Percentage and number of males, females and intersexual individuals as a function of length in *P. bogaraveo*.

LENGTH (cm)	MALES		INTERSEXUAL IND.		FEMALES		
	N	%	N	%	N	%	N total
22	4	67	1	16	1	17	6
23	11	65	3	17	3	18	17
24	11	48	10	43	3	13	23
25	26	58	18	40	1	2	45
26	30	49	26	43	5	8	61
27	16	40	22	55	2	5	40
28	19	32	34	57	7	12	60
29	22	37	30	50	8	13	60
30	23	32	35	49	14	19	72
31	17	20	38	45	29	35	84
32	20	21	43	46	31	33	94
33	18	23	32	42	27	35	77
34	21	23	37	41	33	36	91
35	20	24	17	20	46	55	83
36	26	27	19	20	52	54	97
37	21	26	23	28	38	46	82
38	20	33	7	11	34	56	61
39	22	35	11	17	30	48	63
40	6	17	2	14	28	69	36
41	7	20	3	9	25	71	35
42	5	19	2	7	20	74	27
43	5	14	3	9	27	77	35
44	6	55	2	18	3	27	11
45	1	11	0	0	8	89	9
46	1	14	1	15	5	71	7
47	0	0	0	0	3	100	3
48	1	33	0	0	2	67	3
49	1	33	2	67	0	0	3
50	1	25	1	25	2	50	4
51					2	100	2
52					0	0	0
53					0	0	0
54					1	100	1
Total	381	29%	420	32%	492	38%	1293

females to be more abundant in the catch than males and intersexual individuals. However, a significant trend was evident when sex-ratios were calculated for each length class (Table I). Males dominated the length intervals between 22 and 26 cm and intersexual individuals between 27 and 34 cm. Females were the most abundant in groups > 34 cm, with the exception of lengths 44 and 49 cm (a small number of specimens). Thus *P. bogaraveo* in Azorean waters displayed protandric hermaphrodism, and intersexual individuals were most common in the length intervals of 27-34 cm.

In intersexual individuals three types of ovotestis were observed, as observed by Lamrini (1986) in *Pagellus acarne*: functional testes with ovarian tissue - the ovarian part is halted at the early stage of gametogenesis - (Mf); gonads in which male and female parts were of approximately the same size, but the functional part was not well defined (mf); and functional ovaries with a degenerated testicular part (mF). These intersexual individuals appeared with percentages of: Mf 55%; mf 40%; and mF, the least common, 4%.

Sex-ratios were calculated by season for each year (Fig. 4). Males were most abundant in autumn and winter samples and intersexual individuals in summer samples. During this season, next to the spawning period which takes place in spring, it seems to be more suitable for the transition from post-spawning male (MF) (stage III) to early maturing female (stage I). Analysing intersexual individuals by season (Fig. 5), it is interesting to note the existence of intersexual mF only during spring and summer months. In Table II, variation in these three

Table II: Percentage and number of three different stages of intersexuality (Mf, mf and mF) as a function of length in *P. bogaraveo*.

LENGTH (cm)	INTERSEXUAL INDIVIDUALS mf		Mf		mF		N total
	N	%	N	%	N	%	
22	1	100					1
23	3	100					3
24	7	78	1	11	1	11	9
25	14	78	3	17	1	6	18
26	21	81	5	19	0	0	26
27	14	64	7	32	1	5	22
28	22	65	11	32	1	3	34
29	16	53	12	40	2	7	30
30	14	40	20	57	1	3	34
31	16	42	18	47	4	12	38
32	7	16	35	81	1	2	43
33	6	19	26	81	0	0	32
34	7	19	28	76	2	5	37
35	7	41	9	53	1	6	17
36	6	32	11	58	2	11	19
37	4	17	19	83	0	0	23
38	2	29	5	71	0	0	7
39	1	9	10	91	0	0	11
40	1	50	1	50	0	0	2
41			2	67	1	33	3
42			2	100			2
43			3	100			3
44			2	100			2
45			0	0			0
46			1	100			1
47			0	0			0
48			0	0			0
49			0	0			0
50			1	100			1
Total	170	40%	232	55%	18	4%	420

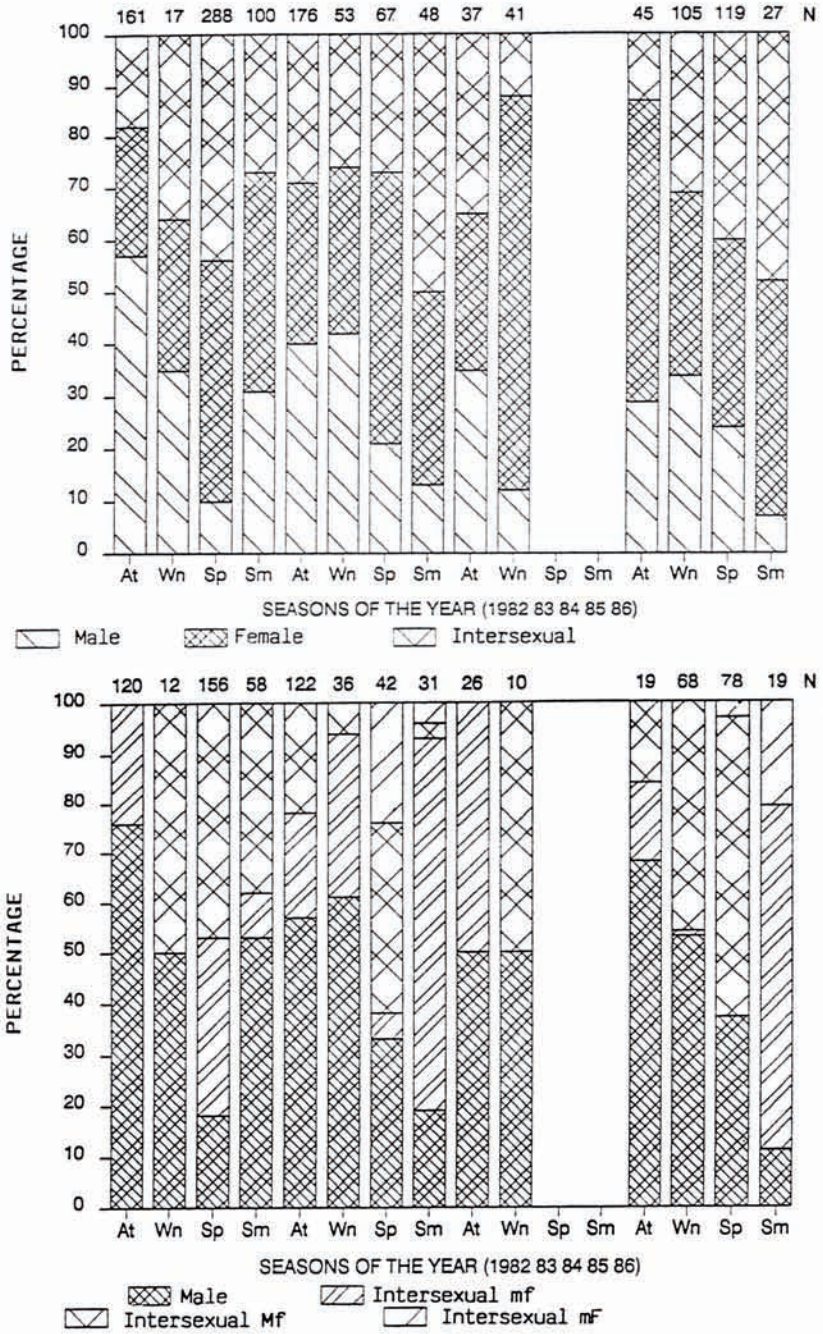
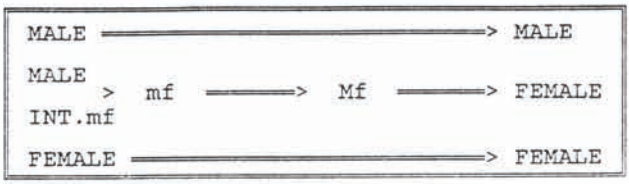


Fig. 4: Seasonal variation of males, females and intersexual individuals as percentages. Autumn 1982 - summer 1986. N = number of fish.
Fig. 5: Seasonal variation of males and intersexual individuals in three stages of inversion (Mf, mf and mF) as percentages. Autumn 1982-summer 1986. N = number of fish.

stages is presented by length groups. Hence, intersexual mf were more common at lengths of 22-29 cm and Mf at lengths of > 29 cm.

Separating sex variation by length for *P. bogaraveo* is presented in the diagram:



Hence, there are: adult males where the transition does not take place; small primary females that will become adult females; males that will undergo the transition becoming first intersexual mf then Mf and then females; and intersexual individuals that will undergo mf and Mf and then become females. Similar changes have been documented in the sparid *Pagellus acarne* (Lamrini, 1986) and in the gonostomatid *Gonostoma elongatum* (Fisher, 1983).

Fecundity

Fecundity, defined as the number of ripening eggs in females prior to spawning (Bagenal *et al.*, 1986) was determined in 75 specimens sampled in 1984, 1985 and 1986. Fish selected were in stage II, and oocytes with diameters larger

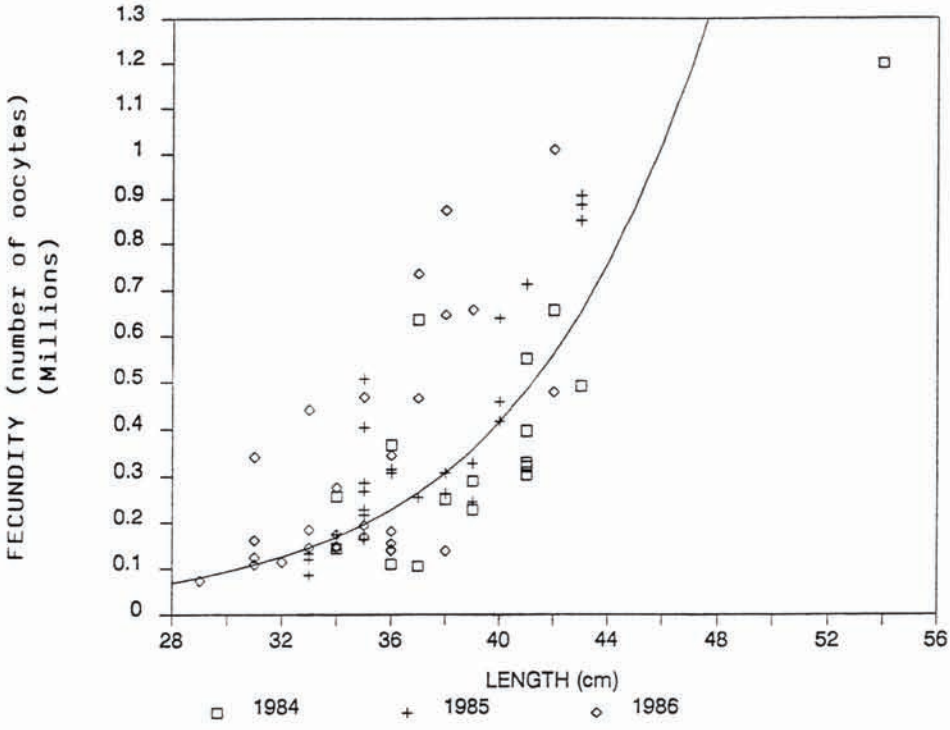


Fig. 6: Relationship of fecundity to length for *P. bogaraveo*. 1984-1986.

than 300 μm were considered maturing. The number of maturing oocytes for both ovaries was calculated from the ovary sampled. Fecundity estimates ranged from 73 000 to 1 500 000 oocytes, for fishes between 29 and 41 cm lengths. Plots of fecundity versus length (Fig. 6), fecundity versus total weight and fecundity versus ovary weight, indicated an exponential relationship for fecundity versus length and linear relationships for both fecundity versus total and ovary weight.

Fecundity versus length relationship was expressed by the equation:

$$F = ae^{bL}$$

where F is fecundity in number of oocytes and L the length in cm. Correlation coefficient (r) was 0.74.

The following equation was calculated:

$$F = 1028.44\ e^{0.15\ L}.$$

The relationships between fecundity and total weight and fecundity and ovary weight were expressed by the equation:

$$F = a + bX$$

where F is fecundity and X total weight (W) or ovary weight (w). Hence, the following equations were obtained:

$$F = 596.85\ W - 270370.11$$

with a correlation coefficient (r) of 0.79 and

$$F = 34598.48 + w\ 5875.96$$

with r = 0.73.

DISCUSSION

Blackspot seabream spawn in Azorean waters from January to April with peak spawning activity in February and March. In Cantabrian waters spawning occurs at the same period (Sanchez, 1983). In England, spawning starts in September and is finished in October (Olivier, 1928).

In the Azores, sex transition takes place mostly at sizes of 28-34 cm, fork length. In Cantabrian waters, however, it occurs at smaller sizes (Sanchez, 1983). Length at first maturity was at an average of 27.7 cm for males and 34.6 cm for females, which corresponds to lengths of ages 5 and 8, respectively. In the Cantabrian Sea, Sanchez (1983) found that first maturity occurs at an age of 5 years. The growth rate of *P. bogaraveo*, however, is slower in Azorean waters (Krug, 1989). According to Olivier (1928) the age at first maturity is 4 years.

Fecundity estimates ranged from 73 000 to 1 500 000 oocytes for fish between 29 and 41 cm (ages 6 and 11 respectively). Fecundity estimates given by Olivier ranged between 70 000 (31 cm - age 8) and 500 000 oocytes (41 cm).

This study presents evidence for protandry in *P. bogaraveo*, and also showed variability in the expected pattern of protandric hermaphrodism, which indicates that not all individuals change sex. Overlaps in length groups of males and females of smaller sizes, suggests that a portion of the population matures directly as primary females. Also, the same overlap in larger sizes, suggests that a portion of the males in the population do not change sex. The occurrence of intersexual individuals (mf) smaller than the size range of mature males may indicate that some individuals change sex before functioning as males. Variation in the size at which sex is changed should not be unexpected, since fish populations may change the age at which they change sex as an adaptive response to population changes.

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